Decoding the Amplitude-Modulated Part the DCF77 Longwave Time Signal by using the Goertzel Algorithm

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***Abstract*—The DCF77, a long wave time signal transmitter that is located near Frankfurt am Main in Germany, is the primary source of time information for radio-controlled clocks in Europe. Its signal consists of a phase and an amplitude-modulated part, both containing the time information. Devices that use the signal usually consist of an amplitude modulation long wave receiver, often realized by using a dedicated integrated circuit, and an application processor. In this paper, a novel approach for the demodulation of the amplitude-modulated part of the signal, without the need for specialized analog cicruitry and only a minimal amount of simple hardware components, is presented. This is done by utilizing direct-sampling software-defined radio techniques together with leveraging the efficiency of the Goertzel algorithm. As a result, the presented approach removes the need for most of the usually employed analog circuitry, leaving only a front-end amplifier, and effectively proposes a new type of design where the receiver is implemented inside the application processor. The employed lightweight algorithms keep it realizable on a system with limited resources, which is shown in an example implementation on a Arm Cortex-M3 microcontroller.**

***Index Terms*—DCF77, SDR, Goertzel, DSP, Time Signal**

I. Introduction

This document is a model and instructions for LaTeX. Please observe the conference page limits. For more information about how to become an IEEE Conference author or how to write your paper, please visit IEEE Conference Author Center website: https://conferences.ieeeauthorcenter.ieee.org/.

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Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections II-A to II-H below for more information on proofreading, spelling and grammar.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

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Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

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- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
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- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
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Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

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TABLE I
TABLE TYPE STYLES

Table Head	Table Column Head		
	Table column subhead	*Subhead*	*Subhead*
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[a]Sample of a Table footnote.

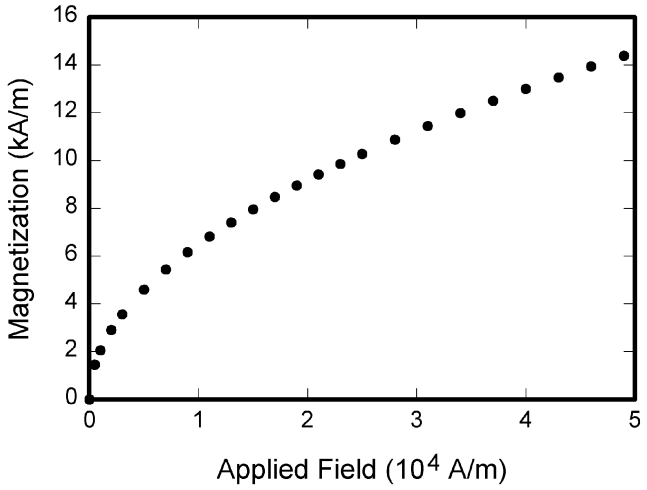

Fig. 1. Example of a figure caption.

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ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

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